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TITLE: INDUCTION-HARDENED PARTS

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ABSTRACT:

PROBLEM TO BE SOLVED: To provide an induction-hardened parts securing a static strength of automotive power transmission system parts such as axle shafts, drive shafts, outer races for equal velocity joints or the like and furthermore excellent in impact bendability and impact twisting resistance.

SOLUTION: This parts is the one having a compsn. contg., by weight, 0.30 to 0.60% C, ≤0.50% Si, 0.20 to 1.50% Mn, 0.0005 to 0.0050% B, ≤0.015% N, ≤0.10% Ti, and the balance Fe with impurities, in which surface hardness after induction hardening treatment is

regulated to ≥50HRC, furthermore having a uniform martensitic structure in which the rate of martensite in the induction- hardened structure is regulated to ≥90%, and in which the ratio of hardening depth (t), i.e., (effective hardening depth)/r (the parts radius or parts thickness) is regulated to 0.2 to 0.7.

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(54)【発明の名称】　高周波焼入れ部品

(57)【要約】
【課題】　アクスルシャフト、ドライブシャフト、等速ジョイント用アウターレースなどの自動車の動力伝達系の部品の静的強度を確保し、かつ、衝撃曲げ特性及び耐衝撃ねじり特性に優れた高周波焼入れ部品を提供すること。
【解決手段】　重量%で、Ｃ：０．３０～０．６０%、Ｓｉ：≦０．５０%、Ｍｎ：０．２０～１．５０%、Ｂ：０．０００５～０．００５０%、Ｎ：≦０．０１５%、Ｔｉ：≦０．１０%含み、残部Ｆｅ及び不純物からなり、高周波焼入れ処理後の表面硬さが≧５０ＨＲＣ、かつ、高周波焼入れ部組織のマルテンサイト率が９０%以上の均一なマルテンサイト組織であり、硬化深さ比ｔ（有効硬化深さ）／ｒ（部品半径または部品厚さ）が０．２～０．７である高周波焼入れ部品。

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【特許請求の範囲】

【請求項１】　重量％で（以下同じ。）、Ｃ：０．３０～０．６０％、Ｓｉ：≦０．５０％、Ｍｎ：０．２０～１．５０％、Ｂ：０．０００５～０．００５０％、Ｎ：≦０．０１５％、Ｔｉ：≦０．１０％含み、残部Ｆｅ及び不純物からなり、高周波焼入れ処理後の表面硬さが≧５０ＨＲＣ、かつ、高周波焼入れ部組織のマルテンサイト率が９０％以上の均一なマルテンサイト組織であり、硬化深さ比ｔ（有効硬化深さ）／ｒ（部品半径または部品厚さ）が０．２～０．７であることを特徴とする高周波焼入れ部品。

【請求項２】　Ｃｒ：≦１．０％、Ｍｏ：≦０．５％及びＮｉ：≦１．０％の１種または２種以上を含有することを特徴とする請求項１記載の高周波焼入れ部品。

【請求項３】　Ｐｂ：≦０．２０％、Ｓ：≦０．１０％、Ｂｉ：≦０．２０％、Ｔｅ：≦０．１０％及びＣａ：≦０．０１％のうちの１種または２種以上を含有することを特徴とする請求項１または請求項２記載の高周波焼入れ部品。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、耐衝撃曲げ特性、耐衝撃ねじり特性などの衝撃特性に優れた高周波焼入れ部品に関する。

【０００２】

【従来の技術】自動車の動力伝達系を構成する部品、例えばアクスルシャフト、ドライブシャフト、等速ジョイント用アウターレースなどは、高周波焼入れ処理を施して使用されているものである。近年、自動車の高出力化の進行にともなってこれらの動力伝達系の部品の強度を確保し安全性を保証するために、従来の静的強度に加えて優れた疲れ特性、耐衝撃曲げ特性、耐衝撃ねじり特性などの衝撃特性が要求されており、また高強度の材料が要望されている。

【０００３】従来、上記の動力伝達系部品の多くは、ＪＩＳ　Ｓ４０Ｃなどの機械構造用炭素鋼が主に使用されており、熱間鍛造、冷間鍛造、転造、切削加工などによって部品を製造した後、高周波焼入れすることによって要求される強度を得ていた。また、静的ねじり強度を向上させるためには、部材の硬さを高くすること、高周波焼入れ時の焼入れ深さを深くすることなどが有効であることが知られており、炭素含有量を増加させ高周波焼入れ後の硬さを高くするか、焼入れ深さを深くすることで静的強度の改善が達成されてきた。しかし、従来の炭素鋼では、炭素量を増加し硬さを上昇させたり、または焼入れ深さを深くしたりすると、衝撃強度が大幅に低下し、静的強度と耐衝撃曲げ、耐衝撃ねじり強度を両立させることはできなかった。

【０００４】

【発明が解決しようとする課題】本発明は、アクスルシャフト、ドライブシャフト、等速ジョイント用アウターレースなどの自動車の動力伝達系の部品の静的強度を確保し、かつ、耐衝撃曲げ特性及び耐衝撃ねじり特性に優れた高周波焼入れ部品を提供することを目的とするのである。

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【０００５】

【課題を解決するための手段】上記目的を達成するために、本発明の高周波焼入れ部品においては、Ｃ：０．３０～０．６０％、Ｓｉ：≦０．５０％、Ｍｎ：０．２０～１．５０％、Ｂ：０．０００５～０．００５０％、Ｎ：≦０．０１５％、Ｔｉ：≦０．１０％含み、必要に応じてＣｒ：≦１．０％、Ｍｏ≦０．５％及びＮｉ：≦１．０％の１種または２種以上を含み、更に必要に応じてＰｂ：≦０．２０％、Ｓ：≦０．１０％、Ｂｉ：≦０．２０％、Ｔｅ：≦０．１０％及びＣａ：≦０．０１％のうちの１種または２種以上を含み、残部Ｆｅ及び不純物からなり、高周波焼入れ処理後の表面硬さが≧５０ＨＲＣ、かつ、高周波焼入れ部組織のマルテンサイト率が９０％以上の均一なマルテンサイト組織であり、硬化深さ比ｔ（有効硬化深さ）／ｒ（部品半径または部品厚さ）が０．２～０．７であるものとしたことである。

【０００６】

【作用】本発明は、Ｃ含有量を増加させて静的強度を高くした場合においても、Ｂ、Ｔｉを添加することによって耐衝撃曲げ特性及び耐衝撃ねじり特性を向上させ、かつ、Ｍｎ、Ｃｒ、Ｂの効果よって焼入性を向上させて高周波焼入れ深さを十分確保するようにし、さらに、Ｍｏ、Ｎｉの添加によって静的強度及び衝撃特性を改善したものである。

【０００７】以下に各合金元素の組成範囲、高周波焼入れ処理後の表面硬さなどの限定理由について説明する。

Ｃ：０．３０～０．６０％

Ｃは、機械部品の強度を確保するために必須の元素であり、高周波焼入れ後の部品表面部の硬さを５０ＨＲＣ以上とするためには０．３０％以上含有させる必要がある。しかし、０．６０％を超えて含有しても表面硬さは上昇せず、また高周波焼入れ時に焼き割れを発生するなどの問題があるために、その上限を０．６０％とした。

【０００８】Ｓｉ：≦０．５０％

Ｓｉは、脱酸剤として、また、焼入性を高くする元素であるが、０．５０％を超えて添加すると、熱間加工時に割れが発生しやすくなるので、その上限を０．５０％とした。

Ｍｎ：０．２０～１．５０％

Ｍｎは、Ｓｉと同様に脱酸剤として、また、鋼の焼入性を高くする元素である。鋼の高周波焼入れ性を改善し、かつ、表面硬さを増加するためには０．２０％以上添加する必要がある。しかし、１．５０％を超えて添加してもその効果は飽和し、また熱間加工性を低下させるので、その上限を１．５０％とした。

【0009】B：0．0005～0．0050%
溶解性のBは、高周波焼入性を向上させるとともに耐衝撃曲げ、耐衝撃ねじり特性を改善する効果を有する元素である。これらの効果を得るためには少なくとも0．0005%を含有する必要があるが、0．0050%を超えて含有してもその効果は飽和し、圧延や鍛造などの熱間加工で割れを発生しやすくなるなどの問題が生じるため、その上限を0．0050%とした。

【0010】N：≦0．015%
Nは、鋼の溶製段階において入る不可避の元素であり、鋼中のBと結合してBNを生成し焼入性を低下するが、0．015%以下であれば、耐衝撃曲げ、耐衝撃ねじり特性に影響を及ぼさないので、その上限を0．015%とした。好ましくは0．005%以下である。

【0011】Ti：≦0．10%
Tiは、鋼中のNと結合してTiNを生成することによってNを固定し、鋼中の溶解性のB量を増加させる効果を有するため、N量に応じて添加する。Ti／N比率が3．42以上かつ8以下であることが望ましい。なお、Tiを多量に添加しTi／N比が8を超えた場合には、鋼中への介在物の生成が顕著になり疲れ特性を低下させるため、Ti／N比は8以下が望ましく、またTi含有量の上限を0．1%とした。

Cr：≦1．0%
【0012】Crは、Mnと同様に鋼の焼入性を向上する元素であり、必要に応じて添加することができる。高周波焼入れする部品の直径または厚さが25mm以下の場合にはCr添加は不要であるが、比較的に大型の部品を高周波焼入れする場合には、焼入れ性を改善するために添加することが望ましい。しかし、1．0%以上添加すると被削性や熱間加工性などの製造性を悪化させるため、上限を1．0%とした。

Ni：≦1．0%、Mo：≦0．5%
Ni及びMoは、鋼の靭性を向上するとともに、高周波焼入れ部、非焼入れ部の衝撃特性を改善し、耐衝撃曲げ、耐衝撃ねじり特性を向上させるため、必要に応じて添加することができる。なお、Niは1．0%、Moは0．5%を超えて含有させると、被削性や熱間加工性の悪化を助長させることなる。

【0013】Pb：≦0．20%、S：≦0．10%、Bi：≦0．20%、Te：≦0．10%及びCa：≦0．01%
Pb、S、Bi、Te及びCaは、被削性を改善する元素である。しかし、Pbを0．20%、Sを0．10%、Biを0．20%、Teを0．10%及びCaを0．01%を超えて添加すると、疲れ特性や転動疲れ特性を低下させる。また介在物として鋼中に存在するため、多量に含有させると耐衝撃曲げ、耐衝撃ねじり特性を低下させる。

【0014】高周波焼入れ処理後の表面硬さ：≧50HRC
高周波焼入れ処理後の部品表面硬さは、静的強度、耐摩耗性、疲れ特性、耐衝撃曲げ及び耐衝撃ねじり特性を決定するが、これらの特性を改善するためには少なくとも表面硬さを50HRC以上必要である。焼入れ硬さが、50HRCより低くなると疲れ特性や静的強度が低下し、耐衝撃曲げ、耐衝撃ねじり特性のバラツキが大きくなるため、焼入れ硬さの下限を50HRCとした。

【0015】高周波焼入れ部組織のマルテンサイト率が90%以上の均一なマルテンサイト組織
特に、耐衝撃曲げ及び耐衝撃ねじり特性を改善するには、高周波焼入れ部の組織を均一なマルテンサイトとすることが重要であり、また90%以上をマルテンサイト組織とすることが必要である。マルテンサイト率が低くフェライト・パーライト組織を含む場合には、耐衝撃曲げ、耐衝撃ねじり特性が低下するため、マルテンサイト率を90%以上とすることが望ましい。

【0016】高周波焼入れ時の硬化深さ比t／r：0．2～0．7
高周波焼入れ時の硬化深さは、部品の強度特性に影響を及ぼすため、焼入れ深さ（t）と部品半径または部品厚さ（r）との比、すなわち高周波焼入れ時の硬化深さ比を0．2～0．7の範囲とした。t／rが0．2より小さい場合には、転動疲れ特性が低下し、静的強度も不足する。また、耐衝撃曲げ、耐衝撃ねじり強度も急激に低下するため、硬化深さ比t／rの下限を0．2とした。また、t／rを大きくすることによって耐衝撃曲げ、耐衝撃ねじり特性、静的強度などの強度は向上するが、0．7を超えて硬化深さを深くしても効果が飽和するとともに、高周波焼入れ処理時に焼き割れを生じやすくなるため、t／rの上限を0．7とした。

【0017】
【発明の実施の形態】以下、本発明の実施例を説明する。下記表1に示した成分組成の鋼を通常の方法で溶製し、ビレットにした後このビレットを熱間圧延してφ30mmの丸棒にした。この成分組成の鋼の高周波焼入性を評価するため、φ30mmの丸棒からφ25mm、長さ150mmの丸棒試験片を作製し、高周波焼入れ試験機によって高周波焼入れした後、表面硬さ及び50HRC以上の硬さが得られる深さ（硬化深さ）を測定した。なお、高周波焼入れは、周波数10kHz、出力55kW、加熱時間4秒とし、加熱後に水冷した。また、硬さ測定はロックウェル硬さ計を使用した。その結果を下記表2に示す。

【0018】
【表1】

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表　1

	No	成分組成 (重量%)											
		C	Si	Mn	s－B	N	Ti	Cr	Mo	Ni	S	Pb	その他
本発明鋼	1	0.33	0.11	0.71	0.0016	0.008	0.040	0.15	—	—	0.016	—	—
	2	0.40	0.09	0.71	0.0017	0.007	0.041	0.16	—	—	0.015	—	—
	3	0.50	0.08	0.70	0.0019	0.009	0.040	0.15	—	—	0.016	—	—
	4	0.59	0.11	0.71	0.0015	0.009	0.043	0.17	—	—	0.015	—	—
	5	0.42	0.11	0.65	0.0035	0.010	0.041	0.05	—	—	0.015	—	—
	6	0.42	0.29	0.61	0.0020	0.009	0.055	0.51	—	—	0.016	—	—
	7	0.41	0.49	0.65	0.0016	0.009	0.044	0.98	0.15	—	0.017	—	—
	8	0.41	0.21	0.25	0.0019	0.005	0.039	0.15	0.49	—	0.015	—	—
	9	0.40	0.15	0.99	0.0019	0.007	0.033	0.15	—	0.50	0.017	—	—
	10	0.41	0.10	1.48	0.0020	0.008	0.036	0.15	—	0.98	0.014	—	—
	11	0.41	0.10	0.71	0.0015	0.008	0.036	0.16	—	—	0.051	—	—
	12	0.41	0.14	0.71	0.0017	0.009	0.039	0.17	—	—	0.048	0.13	—
	13	0.42	0.16	0.71	0.0016	0.007	0.039	0.16	—	—	0.016	—	Bi:0.13
	14	0.43	0.16	0.75	0.0017	0.008	0.031	0.15	—	—	0.048	—	Te:0.08
	15	0.42	0.22	0.71	0.0016	0.009	0.034	0.15	—	—	0.028	0.08	Ca:0.003
比較例鋼	1	0.42	0.21	0.71	<0.0002	0.010	0.036	0.11	—	—	0.016	—	—
	2	0.29	0.25	0.75	<0.0002	0.009	0.001	0.21	—	—	0.018	—	—
	3	0.65	0.07	0.65	<0.0002	0.010	0.001	0.18			0.020	—	
	4	0.41	0.25	0.75	<0.0002	0.022	0.002	0.02			0.016	—	
	5	0.41	0.24	0.20	<0.0002	0.010	0.003	0.04			0.015	—	
	6	0.41	0.23	0.11	<0.0002	0.009	0.020	0.04			0.015	—	
	7	0.41	0.22	2.01	<0.0002	0.010	0.001	0.02			0.015	—	

【0019】　　＊　＊【表2】

表　2

	No	表面硬さ（HRC）	50HRCが得られる深さ（mm）	硬化深さ比　t／r
本発明鋼	1	53	6.4	0.51
	2	59	6.8	0.54
	3	64	6.7	0.54
	4	66	7.4	0.59
	5	61	6.8	0.54
	6	60	7.1	0.57
	7	60	7.7	0.62
	8	61	7.2	0.58
	9	59	7.3	0.58
	10	60	7.8	0.62
	11	61	6.4	0.51
	12	59	6.3	0.50
	13	60	6.4	0.51
	14	61	6.3	0.50
	15	61	6.2	0.50
比較例鋼	1	55	4.1	0.33
	2	47	0	0
	3	65	4.3	0.34
	4	56	4.8	0.38
	5	58	3.2	0.26
	6	56	3.2	0.26
	7	57	5.8	0.46

【0020】また、疲れ特性を評価するために、試験部直径22mmの平滑ねじり試験片を使用し、高周波焼入れ処理した後に油圧式ねじり試験機によって1500N・mトルクを負荷し、破断までの繰り返し数を評価した。なお、高周波焼入れは、周波数10kHz、出力5＊5kW、加熱時間2秒とし、加熱後に水冷した。その結果を下記表3に示す。

【0021】

【表3】

表　3

鋼種		表面硬さ (HRC)	硬化深さ比 t／r	静的ねじり破断トルク (N・m)	破断繰り返し数 (回)
本発明鋼	1	53	0.51	4,250	334,700
	2	59	0.54	5,350	556,500
	3	64	0.54	6,220	678,000
	4	66	0.59	6,550	778,900
	5	61	0.23	4,890	378,500
	6	60	0.67	6,780	544,700
	7	60	0.62	5,780	768,400
	8	61	0.58	6,290	777,300
	9	59	0.58	6,330	664,600
	10	60	0.62	6,980	613,400
	11	61	0.51	5,880	443,200
	12	59	0.50	5,560	412,600
	13	60	0.51	5,440	598,900
	14	61	0.50	5,800	435,300
	15	61	0.50	5,770	404,500
比較例鋼	1	55	0.41	4,330	121,100
	2	47	0.19	3,250	2,300
	3	65	0.44	5,530	231,400
	4	56	0.35	3,590	122,700
	5	58	0.28	3,290	45,700
	6	56	0.22	3,350	6,700
	7	57	0.43	4,580	99,800

【００２２】また、衝撃曲げ特性を評価するため、高周波焼入れ処理された試験部直径１０ｍｍの平滑曲げ試験片を用い、３点衝撃曲げ試験において支点間隔１００ｍｍの中心点を１００ｍｍ／ｓの速度で変位させ、破断までに示した最大荷重によって評価した。なお、高周波焼入れは、周波数１０ｋＨｚ、出力５５ｋＷ、加熱時間１．５秒とし、加熱後に水冷した。その結果を下記表４に示す。

＊【００２３】さらに、衝撃ねじり特性を評価するため、衝撃曲げ試験と同一形状の試験片を使用し、３０度／ｓのねじり速度で衝撃ねじりトルクを負荷した場合の破断までに示した最大トルクによって評価した。高周波焼入れは衝撃曲げ試験片と同一条件である。その結果を表４に示す。

【００２４】

＊　【表４】

表　4

	No.	表面硬さ（HRC）	硬化深さ比　t／r	衝撃ねじり最大トルク N・m	衝撃曲げ最大荷重
本発明鋼	1	54	0.55	7,250	109
	2	59	0.56	8,940	139
	3	63	0.53	11,230	155
	4	66	0.57	12,230	188
	5	62	0.25	5,950	83
	6	61	0.69	8,450	155
	7	60	0.61	7,980	163
	8	61	0.53	9,890	176
	9	59	0.51	9,210	188
	10	61	0.65	8,980	194
	11	62	0.55	7,960	137
	12	61	0.55	7,230	133
	13	61	0.57	7,100	141
	14	62	0.54	6,980	137
	15	62	0.53	7,390	133
比較例鋼	1	54	0.41	1,200	76
	2	44	0.15	1,190	26
	3	65	0.48	1,340	77
	4	55	0.36	1,560	35
	5	58	0.24	1,090	33
	6	54	0.22	980	22
	7	58	0.48	1,170	39

【００２５】表２に示されるように、出力５５ｋＷ、加熱時間４秒として一定条件で高周波焼入れをした場合、本発明鋼ではいずれの鋼種においても硬化深さ比（ｔ／ｒ）は０．５以上の値を示しているいるのに対して、比較例鋼では硬化深さ比が浅めになっていることが分かる。特に、Ｃ、Ｍｎ含有量が同一レベルであってもＢ量が異なる場合には硬化深さ比の差が顕著であり、Ｂが高周波焼入れ性に寄与していることが明確である。またＣ量が０．３％未満では表層部の硬さを５０ＨＲＣ以上とすることは困難であることが分かる。

【００２６】表３に示されるように、静的ねじり強度をみると、表層硬さが高く、かつ、硬化深さ比の高いものほど最大ねじりトルクが大きくなることが分かる。比較例鋼では、表面硬さが高くても硬化深さが浅いために、静的ねじりトルクは低い値を示している。また、疲労試験における破断寿命をみると、本発明鋼のほうが破断寿命が長い傾向を示しており、静的にも動的にも、本発明鋼のほうが優位であることが分かる。

【００２７】表４に示されるように、本発明鋼の硬化深＊さ比は０．２５～０．７の範囲において特性を確認したが、比較例鋼に比べて２倍以上の衝撃強度の改善が確認された。硬化深さ比が小さい場合には、衝撃強度も低下する傾向にはあるが、いずれも比較例鋼にくらべて高強度が達成されている。

【００２８】このように、本発明鋼は、比較例鋼に比べて高周波焼入性に優れており、静的強度を低下することなく、耐衝撃曲げ強度、耐衝撃ねじり強度の大幅な向上を可能とした。

【００２９】

【発明の効果】本発明は、上記構成にしたことにより、次のような優れた効果を奏する。

（１）本発明鋼の高周波焼入れ部品は、優れた高周波焼入れ性を有する。

（２）また、高周波焼入れ時の表面硬さと硬化深さ比を適正な範囲に選定することによって静的ねじり強度やねじり疲労強度を確保し、さらに、耐衝撃曲げ強度と耐衝撃ねじり強度の向上を図ることができる。

フロントページの続き

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[Document Name] Abstract
[Abstract]
[A technical problem] Offer the high frequency hardening parts which secured the static intensity of the parts of a power transfer system of cars, such as an axle shaft, a drive shaft, and an outer race for constant-velocity joints, and were excellent in the shock **** characteristic and the shock-proof torsion characteristic.
[Means for Solution] By weight %, C:0.30 to 0.60%, Si:<=0.50%, Mn:0.20-1.50%, B:0.0005 to 0.0050%, and N:<= -- [it contains Ti:<=0.10% 0.015%, and] Consist of the remainder Fe and impurities and the surface hardness after high frequency hardening processing >=50HRC, And the high frequency hardening parts whose hardening depth ratios t (effective hardening depth)/r (a part radius or part thickness) the rate of martensite of a high frequency hardening part organization is 90% or more of uniform martensitic structure, and are 0.2-0.7.

Document Name] Description

[Title of the Invention] High frequency hardening parts

[Claim(s)]

[Claim 1] weight % -- (-- below the same.) -- C:0.30 to 0.60%, and Si:<= -- 0.50% Mn : 0.20 to 1.50%, B:0.0005 to 0.0050%, N: <= -- [0.015%, contain Ti:<=0.10%, and it consists of the remainder Fe and impurities, and] The high frequency hardening parts characterized by >=50HRC and the rate of martensite of a high frequency hardening part organization being [the surface hardness after high frequency hardening processing] 90% or more of uniform martensitic structure, and the hardening depth ratios t (effective hardening depth)/r (a part radius or part thickness) being 0.2-0.7.

[Claim 2] Cr: The high frequency hardening part according to claim 1 characterized by containing <=1.0%, Mo:<=0.5%, and nickel:<=1.0% of one sort, or two sorts or more.

[Claim 3] Pb: The high frequency hardening part according to claim 1 or 2 characterized by containing 1 of <=0.20%, S:<=0.10%, Bi:<=0.20%, Te:<=0.10%, and Ca:<=0.01% of sorts, and two sorts or more.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the high frequency hardening parts excellent in impact properties, such as the shock-proof **** characteristic and the shock-proof torsion characteristic.

[0002]

[Description of the Prior Art] They are used for high frequency hardening processing by the parts which constitute the power transfer system of a car, for example, an axle shaft, the drive shaft, the outer race for constant-velocity joints, etc., giving. In order to secure the intensity of the parts of these power transfer systems with advance of the high increase in power of a car and to guarantee safety in recent years, in addition to the conventional static intensity, it was tired of excelling, and impact properties, such as the characteristic, the shock-proof **** characteristic, and the shock-proof torsion characteristic, are demanded, and the material of high intensity is demanded.

[0003] Many of above-mentioned power transfer system parts are JIS conventionally. After carbon steel for machine structures, such as S40C, is mainly used and manufactured parts by the forge between heat, the forge between the colds, ****, cutting, etc., the intensity demanded by carrying out high frequency hardening had been obtained. moreover, in order to raise static torsion intensity The improvement of static intensity has been attained by it being known that it is effective to make the hardness of a member high, to make deep the hardening depth at the time of high frequency hardening, etc., and making a carbon content increase, and making the hardness after high frequency hardening high, or making the hardening depth deep. However, in the conventional carbon steel, when the amount of carbon is increased, hardness is raised or the hardening depth was made deep, shock intensity was able to fall sharply and was not able to reconcile static intensity, and shock-proof **** and shock-proof torsion intensity.

[0004]

[Problem to be solved by the invention] This invention aims at offering the high frequency hardening parts which secured the static intensity of the parts of a power transfer system of cars, such as an axle shaft, a drive shaft, and an outer race for constant-velocity joints, and were excellent in the shock-proof **** characteristic and the shock-proof torsion characteristic.

[0005]

[Means for solving problem] In order to attain the above-mentioned purpose, it sets on the high frequency hardening parts of this invention. C:0.30 to 0.60%, Si:<=0.50%, Mn : 0.20 to 1.50%, B:0.0005 to 0.0050%, and N:<= -- [it contains Ti:<=0.10% 0.015%, and] Cr:<=1.0%, Mo<=0.5%, and nickel:<=1.0% of one sort or two sorts or more are included if needed. If needed Furthermore, Pb:<=0.20%, S:<=0.10%, Bi:<=0.20%, 1 of Te:<=0.10% and Ca:<=0.01% of sorts and two sorts or more are included. Consist of the remainder Fe and impurities and the surface hardness after high frequency hardening processing >=50HRC, And it is that the rate of martensite of a high frequency hardening part organization shall be 90% or more of uniform martensitic structure, and the hardening depth ratios t (effective hardening depth)/r (a part radius or part thickness) shall be 0.2-0.7.

[0006]

[Function] [when this invention makes C content increase and static intensity is made high] raising the shock-proof **** characteristic and the shock-proof torsion characteristic by adding B and Ti -- and the effect of Mn, Cr, and B -- hardenability is raised, the high frequency hardening depth is secured enough, and static intensity and an impact property are further improved by addition of Mo and nickel.

[0007] The Reasons for limitation of the composition range of each alloy element, the surface hardness after high frequency hardening processing, etc. are explained below. C:0.30 to 0.60%C is an indispensable element in order to secure the intensity of a machine part, and in order to set the hardness of the bill-of-materials surface part after high frequency hardening to 50 or more HRC, it is necessary to make it contain 0.30% or more. However, even if contained exceeding 0.60%, surface hardness did not go up, and was burned at the time of high frequency hardening, and since there was a problem of generating a crack, it made the maximum 0.60%.

[0008] Si: Although <=0.50%Si was an element which makes hardenability high as ******, since it would become easy to generate a crack at the time of processing between

heat if it added exceeding 0.50%, it made the maximum 0.50%. Mn: 0.20 to 1.50%Mn is an element which makes the hardenability of steel high as ****** like Si. In order to improve the high frequency hardenability of steel and to increase surface hardness, it is necessary to add 0.20% or more. However, since the effect is saturated and the processability between heat was reduced even if it added exceeding 1.50%, the maximum was made into 1.50%.

[0009] B of B:0.0005 - 0.0050% solubility is an element which has the effect of improving shock-proof **** and the shock-proof torsion characteristic while raising high frequency hardenability. In order to acquire these effects, at least 0.0005% needed to be contained, but even if contained exceeding 0.0050%, the effect was saturated, and since problems, such as becoming easy to generate a crack in processing between heat of rolling, a forge, etc., arose, it made the maximum 0.0050%.

[0010] N: Although <=0.015%N was an inescapable element containing in the ingot stages of steel, it combined with B in steel, generated BN and fell hardenability, since it did not affect shock-proof **** and the shock-proof torsion characteristic when it was 0.015% or less, it made the maximum 0.015%. It is 0.005% or less preferably.

[0011] Ti: <=0.10%Ti fixes N by combining with N in steel and generating TiN, and since it has the effect of making the soluble amount of B in steel increasing, it adds it according to the amount of N. It is desirable for Ti/N ratios to be 3.42 or more and 8 or less. In addition, when Ti is added so much and a Ti/N ratio exceeds 8, in order for generation of the intervention thing to the inside of steel to become remarkable and to reduce the tiredness characteristic, as for the Ti/N ratio, eight or less were desirable, and it made the maximum of Ti content 0.1%. Cr: <=1.0%

[0012] Cr is an element which improves the hardenability of steel like Mn, and can be added if needed. When the diameter or thickness of parts which carries out high frequency hardening is 25mm or less, Cr addition is unnecessary, but when carrying out high frequency hardening of the parts large-sized in comparison, adding in order to improve hardenability is desirable. However, the maximum was made into 1.0% in order to worsen manufacturability, such as ****-ed and processability between heat, if it adds 1.0% or more. nickel:<=1.0% and Mo:<= -- 0.5%, since the impact property of a high frequency hardening part and a non-tempering part is improved and shock-proof **** and the shock-proof torsion characteristic are raised while improving the toughness of steel, nickel and Mo can be added if needed. in addition, nickel exceeds 1.0%, Mo exceeds 0.5%, and when it is made to contain, aggravation of ****-ed or the processability between heat is made to promote -- things -- **

[0013] Pb: <=0.20%, S:<=0.10%, Bi:<=0.20%, Te:<=0.10% and Ca:<=0.01%Pb, S, Bi,

Te, and Ca are elements which improve ****-ed. However, if Te is exceeded for Bi 0.20% 0.10%, it exceeds [S] 0.01% for 0.10% and Ca and Pb is added 0.20%, the tiredness characteristic and the rolling tiredness characteristic will be reduced. Moreover, since it exists in steel as an intervention thing, if it is made to contain so much, shock-proof **** and the shock-proof torsion characteristic will be reduced.

[0014] Surface hardness after high-frequency hardening processing: Although the bill-of-materials side hardness after >=50HRC high frequency hardening processing determines static intensity, abrasion resistance, the tiredness characteristic, shock-proof ****, and the shock-proof torsion characteristic, in order to improve these characteristics, it is required for 50 or more HRC in surface hardness at least. When hardening hardness became lower than 50HRC, he got tired, the characteristic and static intensity fell, and since the variation in shock-proof **** and the shock-proof torsion characteristic became large, the minimum of hardening hardness was set to 50HRC.

[0015] In order for the rate of martensite of a high frequency hardening part organization to improve 90% or more of uniform martensitic structure especially shock-proof ****, and the shock-proof torsion characteristic It is important to use the organization of a high frequency hardening part as uniform martensite, and it is required to make 90% or more into martensitic structure. Since shock-proof **** and the shock-proof torsion characteristic fall when the rate of martensite includes a ferrite perlite organization low, it is desirable to make the rate of martensite into 90% or more.

[0016] The hardening depth at the time of hardening depth ratio t/r:0.2 at the time of high frequency hardening - 0.7 high-frequency hardening made a ratio with the hardening depth (t), a part radius, or part thickness (r), i.e., the hardening depth ratio at the time of high frequency hardening, the range of 0.2-0.7 in order to affect the strength property of parts. When t/r is smaller than 0.2, the rolling tiredness characteristic falls and static intensity also runs short. Moreover, since shock-proof **** and shock-proof torsion intensity also fell rapidly, the minimum of hardening depth ratio t/r was set to 0.2. Moreover, although intensity, such as shock-proof ****, the shock-proof torsion characteristic, and static intensity, improved by enlarging t/r, since it burned at the time of high frequency hardening processing and became easy to produce a crack while an effect is saturated, even if it makes the hardening depth deep exceeding 0.7, the maximum of t/r was set to 0.7.

[0017]

[Mode for carrying out the invention] The working example of this invention is explained hereafter. After ingoting steel of the ingredient composition shown in the following table 1 by the usual method and making it a billet, this billet was hot-rolled and it was made

the phi30mm round bar. In order to evaluate the high frequency hardenability of steel of this ingredient composition, after producing phi25mm and a round bar specimen 150mm in length from the phi30mm round bar and carrying out high frequency hardening with a high frequency hardening testing machine, the depth (hardening depth) from which surface hardness and the hardness of 50 or more HRC are obtained was measured. In addition, high frequency hardening was made into the frequency of 10kHz, 55kW of outputs, and cooking time 4 seconds, and was water-cooled after heating. Moreover, hardness measurement used the Rockwell hardness meter. The result is shown in the following table 2.

[0018]

[Table 1]

[0019]

[Table 2]

[0020] Moreover, in order to evaluate the tiredness characteristic, the smooth torsion specimen with an examination part diameter of 22mm was used, after carrying out high frequency hardening processing, load of the 1500 N-m torque was carried out, and the hydraulic torsion testing machine estimated the number of repetitions to a fracture. In addition, high frequency hardening was made into the frequency of 10kHz, 55kW of outputs, and cooking time 2 seconds, and was water-cooled after heating. The result is shown in the following table 3.

[0021]

[Table 3]

[0022] Moreover, in order to evaluate the shock **** characteristic, using the piece of a smooth bending test with an examination part diameter of 10mm by which high frequency hardening processing was carried out, in the three-point shock bending test, the central point with a fulcrum interval of 100mm was displaced at the rate of 100 mm/s, and the maximum load shown by the fracture estimated. In addition, high frequency hardening was made into the frequency of 10kHz, 55kW of outputs, and cooking time 1.5 seconds, and was water-cooled after heating. The result is shown in the following table 4.

[0023] Furthermore, in order to evaluate the shock torsion characteristic, the specimen of the same form as a shock bending test was used, and the maximum torque shown by the fracture at the time of carrying out load of the shock torsion torque at 30 torsion [/s] speed estimated. High frequency hardening is the same conditions as the piece of a shock bending test. The result is shown in Table 4.

[0024]

[Table 4]

[0025] As shown in Table 2, when high frequency hardening is carried out on fixed conditions as 55kW of outputs, and cooking time 4 seconds, with this invention steel, it turns out also in which steel type that the hardening depth ratio is shallower with comparative example steel to it being as for which that the hardening depth ratio (t/r) shows 0.5 or more values. Even if C and Mn content are the same levels especially, when the amounts of B differ, the difference of a hardening depth ratio is remarkable, and it is clear that B has contributed to high frequency hardenability. Moreover, it turns out that it is difficult that the amount of C sets the hardness of a surface part to 50 or more HRC at less than 0.3%.

[0026] As shown in Table 3, when static torsion intensity is seen, it turns out that the maximum torsion torque becomes [surface hardness] high greatly in the higher thing of a hardening depth ratio. With comparative example steel, even if surface hardness is high, since the hardening depth is shallow, static torsion torque shows the low value. Moreover, when the fracture life in fatigue testing is seen, the way of this invention steel shows the tendency for a fracture life to be long, and it turns out that the way of this invention steel is predominance also statically and dynamically.

[0027] As shown in Table 4, the hardening depth ratio of this invention steel checked the

characteristic in the range of 0.25-0.7, but compared with comparative example steel, the improvement of the shock intensity more than 2 double was checked. When a hardening depth ratio is small, it is in the tendency for shock intensity to also fall, but as for all, high intensity is attained compared with comparative example steel.

[0028] Thus, this invention steel was excellent in high frequency hardenability compared with comparative example steel, and it enabled large improvement in shock-proof flexural strength and shock-proof torsion intensity, without falling static intensity.

[0029]

[Effect of the Invention] This invention does the following outstanding effects so by having had the above-mentioned composition. (1) The high frequency hardening parts of this invention steel have the outstanding high frequency hardenability. (2) Moreover, by selecting the surface hardness and hardening depth ratio at the time of high frequency hardening in the proper range, static torsion intensity and torsion fatigue strength can be secured, and improvement in shock-proof flexural strength and shock-proof torsion intensity can be aimed at further.

[Translation done.]

Notification of Reasons for Refusal

Application number: Application for patent Heisei 8-207624
Date of Drafting: Heisei 14(2002) July 29
Patent examiner: Masaki Okui 7516 4K00
Representative/Applicant: Katsumi Arasaki
Applied Provisions: Patent Law Section 29(1), Section 29(2), Patent Law Section 36

This application should be refused for the reason mentioned below. If the applicant has any argument against the reason, such argument should be submitted within 60 days from the date on which this notification was dispatched.

Reason

1. The claimed invention(s) in the each claim listed below of this patent application should not be granted a patent under the provision of Patent Law Section 29 (1)(iii) for the reason that the claimed invention(s) has/have been deemed to be identical with the invention(s) described in the distributed publication(s) listed below in Japan or other foreign countries prior to the filing of patent application. 2. The claimed invention(s) in the each claim listed below of this patent application should not be granted a patent under the provision of Patent Law Section 29 (2) for the reason that the claimed invention(s) could have easily been made by persons who have common knowledge in the technical field to which the claimed invention(s) pertains, on the basis of the invention(s) described in the distributed publication(s) listed below in Japan or other foreign countries prior to the filing of the patent application.
Account <As opposed to Claim 1 and 2 ... 1, 2>
Publication 1: JP,H5-320825,A

The surface hardness overlap invention which requires the composition range of an alloy ingredient for application-concerned Claim 1 and 2 at a publication 1, and according to high frequency hardening is the ratio of layer thickness / axial radius about a quench-hardening-treatment layer at 55 or more HRC(s). Invention of steel for solid shafts for driving shafts which is 0.45 or more is indicated (Claim 1 and paragraph 0016). Since, as for steel of a description, the surface hardness after high frequency hardening processing is over 50HRC in the publication 1, it is thought that a high frequency hardening organization part is the uniform martensitic structure of 90% or more of the rate of martensite. <As opposed to Claim 3 ... 2>
Publication 1: JP,H5-320825,A

Although reference was already made about the publication 1, in order to improve ****-ed in the paragraph 0016 of this literature, making S, Pb, Te, and Ca contain is indicated. <As opposed to Claim 1 - 3 ... 1, 2>
Publication 2: JP,H8-53714,A

In Claim 1 -6 of the publication 2, invention which requires the composition range of an alloy ingredient for application-concerned Claim 1 - 3 is overlapped, and invention of the scroll parts for machine structures whose ratios are 0.3-0.7 as resemble high frequency hardening at hardening layer depth CD to 50% martensite hardness and the radius of a high frequency hardening scroll article is indicated. It is shown in Table 2 in the paragraph 0036 of this literature that "0.05mm surface hardness (HV)" is over 50HRC. Since, as for steel of a description, "the 0.05mm surface hardness (HV)" after high frequency hardening processing is over 50HRC in the publication 1, it is thought that a high frequency hardening organization part is the uniform martensitic structure of 90% or more of the rate of martensite.

3. A description of the detailed description of the invention is the following point, and this application is patent law Patent Law Section 36 4th. The requirements specified to a clause and (6)(2) are not satisfied.

Account

<To Claim 1>, each "this invention steel" in Table 1 of the paragraph 0018 of (1) application-concerned Description contains Cr and S, and the example corresponding to invention concerning application-concerned Claim 1 is not indicated to the detailed description of the invention. (2) The rate of martensite of "high frequency hardening part organization according to claim 1 is 90% or more of uniform martensitic structure. [that the hardening depth ratios t (effective hardening depth)/r (a part radius or part thickness) are 0.2-0.7"] A "high frequency hardening organization" which portion of parts is pointed out Since it is unknown, He cannot understand invention (since the rate of martensite becomes small, it is hard to consider the rate of martensite with hardening that the other portion is divided into two of the portions whose rates of martensite are 0% with 90% or more of portion, as it goes to the depths). (3) The "effective hardening depth" of Claim 1 is not clear in what kind of the depth is pointed out (the portion exceeding 50HRC is pointed out in the detailed description of the invention).

Record of the result of prior art search

- Technical fields to be searched IPC, 7th edition C22C38/-- this Record of the result of prior art search does not constitute a Notification of Reasons for Refusal 00 - 38/60.

If there is hope of the inquiry about the contents of this notice of reasons for rejection or an interview, please contact me to the following. Contact Third Patent Examination Department, the Patent Office Okui Masaki telephone 03-3581-1101 Extension 6994FAX 03-3501-0699